CHAPTER 9
X-RAY EMISSION

X-RAY QUANTITY

X-ray Intensity
- *Units:* R, mR & mGy_a
- *Other Name:* x-ray quantity or radiation exposure

Roentgen
- A measure of the number of ion pairs produced in air by a quantity of x-rays
- *SI Unit:* mGy_a
- *Exposure Rate:* mR/s, mR/min or mR/mAs

X-ray quantity is the number of x-rays in the useful beam!

FACTORS THAT AFFECT X-RAY QUANTITY & IMAGE RECEPTOR

The Effect of Increasing	X-ray Quantity Is	Image Receptor Exposure Is
mAs	Increased proportionately	Increased
kVp	Increased by $(kVp_1/kVp_2)^2$	Increased
Distance	Reduced by $(d_2/d_1)^2$	Reduced
Filtration	Reduced	Reduced

X-ray Quantity & mAs
- X-ray quantity is proportional to the mAs
- *Formula:* $I_1/I_2 = mAs_1/mAs_2$
- *mAs:* mA x s = mC/s x s = mC
- *1 C:* 6.25 x 10^{18} electrons

X-ray Quantity & kVp
- X-ray quantity is proportional to kVp^2
- *Formula:* $I_1/I_2 = (kVp_1/kVp_2)^2$
- *40% Increased in kVp:* doubling the intensity
- *15% Increased in kVp:* reduction of ½ in mAs
    - *Disadvantage:* reduced image contrast

X-ray Quantity & Distance
- X-ray quantity is inversely proportional to the square of the distance from the source
- *Inverse Square Law:* $I_1/I_2 = (SID_2/SID_1)^2$

When SID is increased, mAs must be increased by SID2 to maintain constant exposure to the image receptor!

mAs & SID
- *Square Law:* $mAs_1/mAs_2 = (SID_1/SID_2)^2$

Filtration
- Beam hardening
- *Purpose:* to reduce the number of low-energy x-rays
- *Advantages:* increased beam quality & reduces patient dose
- *Disadvantage:* reduced image contrast

X-RAY QUALITY

X-ray Quality
- The penetrability of an x-ray beam
- It is measured in HVL

Penetrability
- The ability of x-rays to pass through tissue

High Quality X-rays
- X-ray with high penetrability

Low Quality X-rays
- X-ray with low penetrability

Half-Value Layer
- The thickness of absorbing material necessary to reduce the x-ray intensity to half of its original value
- A characteristic of the useful beam
- *Diagnostic X-ray Range:* 3-5 mm Al or 3-6 cm of soft tissue

HVL is the best method for specifying x-ray quality!

Attenuation

- The reduction in x-ray intensity that results from absorption & scattering

Determining Half-Value Layer

- *3 Principal Parts:* x-ray tube, radiation detector & graded thicknesses of filter (Al)
- *Steps:*
  - A radiation measurement is made with no filter between x-ray tube & the detector
  - Measurements of radiation are made for successively thicker sections of filter
  - The thickness of filtration that reduces the intensity to half of its original value is the HVL

X-ray beam quality can be identified by voltage or filtration, but HVL is most appropriate!

FACTORS THAT AFFECT X-RAY QUALITY & X-RAY QUANTITY

	EFFECT ON	
An Increased in	**X-ray Quality**	**X-ray Quantity**
mAs	None	Increased
kVp	Increased	Increased
Distance	None	Reduced
Filtration	Increased	Reduced

X-ray Quality & kVp

- Increasing the kVp peak increases the quality of an x-ray beam

X-ray Quality & Filtration

- Increasing the filtration increases the quality of an x-ray beam but decreases the x-ray quantity
- *Filter Materials:* aluminum (Z=13), copper (Z=29), tin (Z=50), gadolinium (Z=64) & holmium (Z=67)

Types of Filtration

- Inherent & Added Filtration

Inherent Filtration

- *Locations:* x-ray tube glass/metal enclosure & window
- *Equivalent:* 0.5 mm Al

Mammography

- *Window:* beryllium (Z=4)
- *Equivalent:* 0.1 mm Al

Added Filtration

- *Locations:* x-ray tube housing & x-ray beam collimators
- *Equivalent:* 1 mm Al (port of x-ray tube) & 1 mm Al (collimators)

Total Filtration

- 2.5 mm Al
- *Inherent Filtration:* 0.5 mm Al
- *Added Filter:* 1 mm Al
- *Mirror:* 1 mm Al

Compensating Filter

- Material inserted between an x-ray source & a patient to shape the intensity of the x-ray beam
- It is designed to make the remnant beam more uniform in intensity
- *Examples:* wedge filter, trough filter, bow-tie filter & conic filter

Wedge Filter

- It is used for examination of the foot

Trough Filter

- A bilateral wedge filter
- It is used in chest radiography

Bow-Tie Filter

- It is used with CT imaging systems to compensate for the shape of the head or body

Conic Filter

- It is used in digital fluoroscopy

Step-Wedge Filter

- An adaptation of the wedge filter
- It is used in some special procedures, usually when long sections of the anatomy are imaged